

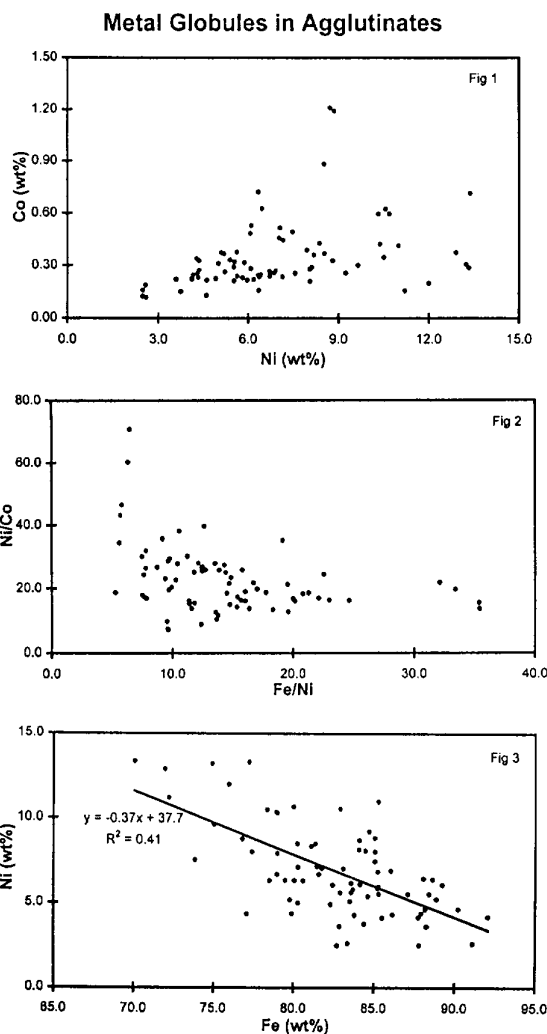
METEORITIC METAL IN APOLLO 16 AGGLUTINATES. A. Basu, M. Dorais, and C. Yokoyama, Department of Geological Sciences, Indiana University, Bloomington IN 47405 (basu@indiana.edu).

Summary: Fe-Ni-Co distribution in metal globules in agglutinates from seven Apollo 16 surface soils suggests that the metal is probably meteoritic in origin, and the excess metal in Apollo 16 soil is nonlunar. If the globules are coalescence products of nanophase superparamagnetic iron (np-Fe⁰), then the origin of np-Fe⁰ is also nonlunar. A weak negative correlation between Fe and Ni in these globules provides the intriguing possibility that they may represent a series of “progressive metamorphism.”

Introduction: Fe-Ni metal globules in the glass of agglutinates were probably liquid drops, immiscible in the silicate melt, that eventually bonded lunar soil grains into agglutinates. Agglutinates formed from minute melts produced by impacting micrometeorites on lunar soils that had been implanted, to variable degrees, with solar wind elements, of which H was by far the most abundant. Indigenous, i.e., pristine, lunar components, upon impact melting, may have been reduced by solar wind H and may have produced immiscible globules of Fe-Ni metal. The same mechanism is likely to have produced np-Fe⁰ that may have coalesced to produce globules, especially if agglutinates have recycled through generations of regolith turnover [1,2]. Korotev [3] argues that the “excess” metal in Apollo 16 soil is lunar in origin. Because much of the metal in soils resides in agglutinates, we are conducting an electron microprobe survey of metal globules in Apollo 16 soils. We report on 76 analyses of metal globules (1–3 μm) in agglutinates from 7 different soils (61161, 61181, 63321, 63341, 63501, 64501, 67941). Criteria developed in the Apollo decade claim that Ni-Co distribution can discriminate between lunar and meteoritic metal [4,5] although subsolidus equilibration may obliterate such distinction [6].

Method: We are following the same analytical procedure reported earlier [7] and continue to use a regulated beam current of 2 na, but using a 15 keV accelerating potential to obtain an electron beam of about 0.7–0.5 μm in diameter. Because metal globules in agglutinates are very small we still get some X-rays from the surroundings and below. We have discarded the analyses that show more than 2% SiO₂ or more than 1% S. Such contamination is unavoidable, but for the present discussion it is not very significant [cf. 5].

Results and Discussion: Our results, except for one globule discussed separately below, are plotted in three binary diagrams (Figs. 1–3). In the standard Ni-Co diagram (Fig. 1) our analyses plot mostly in the meteoritic field of Hewins [4] and all plot in the polymict field, i.e., nonpristine field, of Ryder [5]. Interestingly, none of the globules analyzed show >14% Ni, unlike many lunar metal grains in polymict breccias [5]. Most of the globules that we have analyzed have Fe/Ni < 16 and only a few have Fe/Ni > 20. These additional analyses are compatible with our suggestion [7] that many metal globules in Apollo 16 soils are meteoritic in origin. If the globules are coalescence products of much finer-grained np-Fe⁰, then the standard model of the provenance and origin of np-Fe⁰ may need revision.



We disagree with Korotev [3] that the excess of Fe metal in Apollo 16 soils must be lunar in origin. There is no petro logic data, and we do not have any petrologic notes either to suggest that there may be large metal grains in the regolith or in rock fragments. Most metal phases seen in the lunar regolith reside in agglutinates, which are likely nonlunar. Metal in impact melt rocks and in polymict breccias (60017, 67455) is likely to be nonlunar as well [5].

Our data also show that micrometeorites in the lunar environment did not vaporize fully; parts were melted and incorporated in the impact melt. Globules of projectile components have been found in melted targets in impact experiments [8]. It is true, however, that these experiments did not reach the high velocities 10–20 km/s of impacting micrometeorites on lunar soils; nor were the experiments done under near-vacuum conditions. Yet the similarities between experimental results and observation are remarkable. Therefore, in the light of

experimental and empirical data that are now available, it may be necessary to reexamine models that predict vaporization of hypervelocity projectiles.

Finally, there is an intriguing question of subsolidus reduction of metal, which could produce pure Fe metal [6,9]. One globule in an agglutinate in soil 63341 has 94% Fe and 1.7% Ni. Whereas Fe metal in the liquid phase may scavenge Ni-Co from an immiscible silicate melt, it is possible that subsolidus reactions may drive out the Ni and Co. Our analyses show a weak negative correlation between Fe and Ni, which, at least in part, is an artifact of closure (Fig. 3). They may, however, also show the trend of a series of “progressively metamorphosed” Fe-Ni grains [6,9,10]. The possibility remains intriguing.

References:

- [1] Basu A. (1990) *Proc. LPSC 20th*, 231–238. [2] Kerridge J. F. (1994) *LPS XXV*, 695–696. [3] Korotev R. L. (1987) *Proc. LPSC 17th*, in *JGR*, 91, E447–E461. [4] Hewins R. H. et al. (1976) *Proc. LPSC 7th*, 819–836. [5] Ryder G. et al. (1980) *Proc. LPSC 11th*, 471–479. [6] Taylor L. A. et al. (1976) *Proc. LPSC 7th*, 837–856. [7] Basu A. et al. (1996) *LPS XXVII*, 77–78. [8] Rowan L. R. and Ahrens T. J. (1994) *EPSL*, 122, 71–88. [9] Misra K. and Taylor L. A. (1975) *Proc. LPSC 6th*, 615–639. [10] Mao H. K. and Bell P. M. (1976) *Proc. LPSC 7th*, 857–862.